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UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service
Grain Division

OPERATING THE BROWN-DUVEL MOISTURE TESTER

The air-oven method is designated as the official method for determining moisture in wheat, barley, oats, rye, grain sorghums, flaxseed, soybeans, rice, dry peas, split peas, and lentils under the United States standards. The water-oven method is designated as the official method for corn and beans under the standards. In actual inspection, however, other devices or methods to determine moisture are used that give equivalent results and which are more rapid than the oven methods. The Brown-Duvel moisture tester can be used as one of the methods for determining moisture. This method is used especially for corn which contains a high percentage of moisture.

This tester together with the accessories such as thermometers, flasks, etc., are described in United States Department of Agriculture Department Bulletin 1375, "The Brown-Duvel Moisture Tester and How to Operate It," by D. A. Coleman and E. G. Boerner, and in Supplement 2 to this bulletin issued August 1942. This bulletin is out of print but copies may be available for loan in public libraries or in the field offices of the Grain Division, Agricultural Marketing Service. Specifications for the tester and various accessories can be obtained from General Field Headquarters, Grain Division, Agricultural Marketing Service, United States Department of Agriculture, 1108 Post Office Building, Chicago 7, Illinois.

HOW TO MAKE A MOISTURE TEST

The method of making moisture tests with a Brown-Duvel tester consists of heating the material to be tested in a mineral oil having a flash point much above the boiling point of water, condensing the moisture which distills off, and collecting and measuring the moisture in a suitable graduate.

After properly mixing the bulk sample to be tested, carefully weigh the prescribed quantity for the moisture test and empty it immediately into the distillation flask. Add the prescribed quantity of oil and shake with a slight whirling motion until the two are well mixed.

Insert the No. 5 rubber stopper carrying the thermometer into the neck of the flask. The thermometer should be adjusted so that four-fifths of the mercury bulb is submerged in the oil and grain. It is important to check this adjustment of the thermometer. If the bulb of the thermometer is too near the bottom of the flask, a low moisture test result will be obtained and if the bulb is too high the result will be too high.

When the flask has been placed in the compartment of the tester, connect the side tube of the flask by means of the No. 3 rubber stopper with the mouth of the glass condenser tube which extends down through the cold-water tank, so that the moisture which is driven from the material will be condensed and collected in the graduated cylinder beneath the tank.

Place the cover over the flask, then turn on the electricity or ignite the gas (depending on the type of heat used).

The rate of heating should be adjusted in accordance with instructions under "Standardizing the Tester." When the desired temperature is reached, the electricity or gas should be turned off. If the tester is equipped with an electric cut-off this will be done automatically. After the heat is turned off the thermometer will show a slight gradual increase in temperature of a few degrees. Let the temperature recede to 160° C. before making the reading. Before making the reading, remove the covers, disconnect the flasks from the condenser tubes to allow the small quantity of water which may have collected at the base of the No. 3 rubber stopper to drop into the graduated cylinder.

The amount of moisture which has collected in the graduate is read beneath the layer of oil on top of the water. When 100 grams of grain are used in the test and the graduate is calibrated in milliliters, the number of milliliters of water in the graduate is equal to the percentage of moisture in the grain. Duplicate tests should be made on all samples and if the variation does not exceed 0.3 percent take the average of the two readings as the correct percentage of moisture.

While the contents of the flask are still hot, remove the thermometer, give the flask a slight whirling motion, invert quickly, emptying the contents into a suitable strainer, so that the oil can be recovered for further use.

When the flasks are not in use, keep them in place in the compartments and connected as for a test. In using a new flask for the first time or when the tester has been idle for more than 24 hours, a preliminary test should be made before making a regular test.

HOW TO TEST DIFFERENT MATERIALS

Detailed instructions have been worked out for making moisture determinations of a number of materials as follows:

Commodity or Product	:	:	:Temperature
	:Quan-	:Weight:	at which
	:tity	: of	heat is
	:of oil:	sample:	cut off
	ml.	Gm.	°C.

Grains under the U. S. Grain Standards Act -

Wheat (Hard Red Winter, Hard Red Spring, Durum, and Red Durum)	150	100	180
Wheat (Soft Red Winter and White).	150	100	190

Commodity or Product	:Temperature		
	:Quan-	:Weight:	at which
	tity : of : heat is	of oil:sample: cut off	
	ml.	Gm.	°C.
Corn (Maize) shelled	150	100	190
Barley	150	100	190
Oats, Feed Oats and Mixed Feed Oats. . .	150	100	195
Rye.	150	100	185
Grain Sorghums	150	100	195
Flaxseed	150	100	175
Soybeans	150	100	173
Rice, Beans, and Peas, under permissive			
U. S. standards -			
Rough rice <u>1/</u>	150	100	200
Brown rice <u>1/ 2/ 3/</u>	150	100	200
Milled rice, except Brewers milled rice			
<u>1/ 2/ 3/</u>	150	100	200
Brewers Milled rice <u>1/ 2/ 4/</u>	150	100	200
Parboiled Rice <u>1/</u>	150	100	200
Beans (dry).	150	100	175
Peas (dry).	150	100	180
Split Peas	150	100	175
Other Commodities and Products -			
Buckwheat.	150	100	195
Emmer.	150	100	190
Peanuts (shelled).	150	100	175
Barley malt.	200	100	168
Distillers dried grains.	200	50 <u>5/</u>	190
Corn Meal.	150	50 <u>5/</u>	175
Mustard Seed <u>6/ 7/</u>	150	100	160
Corncobs	250	50 <u>5/</u>	190

- 1/ In making tests of all types of rice the distillate is sometimes cloudy. This in no way affects the accuracy of the test and may be disregarded.
- 2/ Use thermometer guards or cages to minimize super-heating.
- 3/ Use glass-wool pad 3 inches in diameter and 1/4-inch thick in bottom of flask.
- 4/ Use glass-wool pad 4 inches in diameter and 1/4-inch thick in bottom of flask.
- 5/ Use special graduate which is calibrated so that the percentage of moisture can be read directly on the cylinder. If the regular graduate is used the reading must be multiplied by 2 to obtain the percentage of moisture.
- 6/ Use double-wall copper flasks with 150 cubic centimeters of oil in the inner flask and 150 cubic centimeters between the walls.
- 7/ Oil and meal in inner flask should reach a temperature of 176 °C. in about 26 minutes.

STANDARDIZING THE TESTER 1/

Accurate results with a Brown-Duvel moisture tester depend on having the tester adjusted for the proper heating time. This adjustment is made as follows: Place 450 cubic centimeters of oil (the regular moisture-testing oil) at room temperature into a flask and place the flask in a compartment of the tester. The oil should be accurately measured. Insert the thermometer so that the mercury bulb is completely immersed and the top of the bulb is just flush with the surface of the oil and note the temperature of the oil. Connect the flask with the condenser tube, place the cover over the flask, and turn on the electricity or light the gas (depending on the kind of heat used), at the same time noting the time. Apply heat until the temperature of the oil reaches $153^{\circ}\text{C}.$ above the original temperature of the oil, and again note the time. For example, if the thermometer shows the oil temperature to be $22^{\circ}\text{C}.$, a cut-off temperature of $175^{\circ}\text{C}.$ (22 plus 153) is used for this adjustment. The time elapsed should be 20 minutes.

The oil test heating time of 20 minutes is the same regardless of the source of heat energy, whether gas, electricity, or alcohol. If the oil test shows that the time lapse varies from the 20-minute standard by more than 30 seconds, the heater should be adjusted. If the variation is less than 30 seconds, no adjustments are necessary. The adjacent compartments should be heated during the time the test on a specific compartment is being run.

Adjustment of Electric Heaters

Electrically operated Brown-Duvel moisture testers are usually equipped with adjustable type heating units which make it possible to adjust the heating time by lowering or raising the heating elements. If the oil test shows that it takes more than 20-1/2 minutes to reach the proper temperature the heater should be raised. On the other hand, if it takes less than 19-1/2 minutes to reach the proper temperature, the heater should be lowered. A series of oil tests and adjustments should be made until the time required for heating all of the individual compartments is not less than 19-1/2 minutes or more than 20-1/2 minutes.

In the case of Brown-Duvel moisture testers which have been converted from gas to electricity as a source of heat, it is usually necessary to remove the wire gauzes in order to obtain the proper heating time. If the heaters cannot be standardized by adjusting the elements up or down, or by removing the wire gauzes when they are present, the services of a competent electrician are needed.

Adjustment of Gas Burners

The heating time of gas-operated Brown-Duvel moisture testers is controlled by regulating the size of the flame. In some cases the flame is controlled by a needle valve in the base of the burner, in

others by the size of opening in the base. If the oil test shows that it takes more than 20-1/2 minutes to reach the proper temperature, the amount of heat must be increased. To do this, the needle valve is opened to provide more gas to the flame, or if the burner is not equipped with a needle valve, the opening in the base of the burner is enlarged with a reamer. If the oil test shows that it takes less than 19-1/2 minutes to reach the proper temperature the heat is reduced by closing the needle valve or by reducing the size of the opening in the base of the burner by tapping the top of the base with a small hammer. All heating tests should be made with the gas stopcocks completely open. The series of oil tests and adjustments should be continued until the time required for heating all of the individual compartments is not less than 19-1/2 minutes or more than 20-1/2 minutes.

If an automatic gas-pressure regulator is used, and the correct heating time for each burner has been adjusted, as described above, a uniform heating time for all compartments is assured. If, however, a gas governor is not available, it will be necessary for the operator to fix in his mind the flame necessary to heat the tester in the proper time, and in case the gas pressure varies, to compensate for this by adjusting the keys and air valves at the base of the burner.

Adjustment of Brown-Duvel Tester Equipped With Other Type Heaters

Moisture tests can be made with a Brown-Duvel moisture tester heated with alcohol, but time tests cannot be made as well as with gas or electric heating units. In making tests with alcohol the flame is very irregular and needs frequent adjustment of the burner valve during the process of the tests.

SPECIAL POINTS TO BE OBSERVED IN MAKING MOISTURE TESTS:

1. The moisture tester should be installed in a place where it will not be exposed to strong air currents.
2. If gas heat is used, the wire gauze with asbestos center should be kept in good condition, and so adjusted that the flame plays directly on the center of the asbestos.
3. If the compartments are heated by electricity and no wire gauzes are used, the heating elements should be left in place during the cooling-off period. However, when wire gauzes are used the heating elements should be dropped at the end of the heating period.
4. The bottom of the flask should be not less than three-eighths inch above the wire gauze.

5. The column of mercury in the thermometer should be continuous; if broken it should be shaken down or a new thermometer substituted.
6. The sample should be thoroughly mixed before weighing for a test; and unless the test is to be made immediately upon the sample's arrival in the office, it should be placed in an air-tight container.
7. Tests should be made in duplicate, and if duplicates vary by more than 0.3 percent of moisture, another test should be made.
8. The thermometers should be so adjusted that four-fifths of the mercury bulb is submerged in the grain and oil after the grain has been placed in the flask. (Make this adjustment each time. Do not guess.)
9. Correctly graduated thermometers and graduates should be used. Thermometers should be of extra quality and not the ordinary grade because the success of the tests depends largely upon the accuracy of the thermometer.
10. Mushy rubber stoppers must not be used as they absorb some of the moisture that should pass into the graduates.
11. Each graduate should be cleaned and dried before using for a test. (No moisture should be in the bottom or along the sides.)
12. Oil should not be used directly from the previous test. Freshly used oil should be emptied into a large storage can and never directly into the oil-measuring device.
13. A good circulation of cold water should be maintained through the condenser tank.
14. The heating apparatus should be adjusted so that the required temperature as indicated by oil test is reached in 20 minutes + 1/2 minute. A longer time will give results that are too low and a shorter time results that are too high.
15. If the moisture content of the sample is high so that there is a tendency to boil over, the flame should be lowered until a considerable portion of the water is distilled over. If electricity is used as a source of heat, the current should be alternately snapped on and off for a few minutes until the critical boiling-over period is past.
16. The heat should be turned off at the exact temperature prescribed for each grain.
17. After the electricity or gas is turned off, a slight gradual rise in the temperature is to be expected. A sudden increase

or sudden decrease in temperature of several degrees indicates that the heat was too intense during the latter part of the heating, and the test should be repeated.

18. after the temperature has fallen to 160° or lower, the cover should be removed, the thermometer disconnected, and the flask disconnected from the condenser tubes.
19. The percentage of moisture in the graduated cylinder should be read after all the drops clinging to the sides of the graduate have been shaken down. The reading is taken beneath the layer of oil on top of the water.
20. Results of tests should not be expressed more closely than 0.1 percent.
21. If the water which distills over is discolored, except for the cloudy condition which may occur with rice, the substance has evidently been burned and the test should be repeated.
22. When the tester is not in use, thermometers should be kept connected in the flasks and the flasks connected with the distilling tubes in the same manner as for making a test.
23. Before making a test in a new flask, or before using a tester that has not been in use for a 24-hour period, a priming test should be made on a preliminary sample so that all the flasks will be in uniform condition.
24. Scales should be placed on a firm support and care should be taken that they are in balance before a weighing is made.
25. The specific directions given above for making tests do not apply in all instances to modified forms of the Brown-Duvel moisture tester.



